DESIGN AND ANALYSIS BATTERY PACKAGING FOR ELECTRIC VEHICLE (EV)

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Automotive Engineering

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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Date : 25 November 2009

STUDENT'S DECLARATION

I hereby declare that the work in this report is my own research except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

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We certify that the project entitled "*(Design and analysis battery packaging for Electric Vehicle)"* Is written by (*Sibra Mallisi Bin Yussof*.) We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

(Zamri Mohamed)

Examiner Signature

To my beloved mother and father,

Mrs. Rubiah Binti Ghazali
Mr. Wan Khairudin Bin Wan Mohamad

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ABSTRACT

Battery packaging is the packaging where the batteries Lead-acid or Lithium-Ion are kept safe. Battery packaging is installed in car such as electric vehicle, hybrid electric vehicle or the car that needs to convert to the electric vehicle. Batteries selection is made depend on the motor specification that install in the car. The battery packaging are important to make the performance of batteries are stable. The cooling system of battery packaging is used to make the heat flow in battery packaging not exceeding the operating temperature of the batteries. The proposed design is made to reach the design specification of battery packaging. Some of battery packaging is made without cooling system. More criteria needs to consider in order choosing the battery packaging such as cost, weight, available space, compact, maintenances and more. The selection of battery packaging must have all the criteria needed by battery packaging, therefore the analysis are made for selection material and heat transfer from battery packaging to outside of the car. The cooling system is effect most on the performance, weight, cost, and maintenances. For example, the liquid cooling system most effective than air cooling system, but liquid cooling have more deficiency in leakage problem, need more mass to complete the circulate of the cooling system and also higher cost of maintenances. The air cooling system less effective, but the cost is low than liquid, easy maintenance and also less mass. So that, this project is focus on cooling system type air to find most effective cooling system by three proposed design of air cooling system. At the end of this project, a new design of proposed battery packaging has been choose by using Solid Work software. There are some improvements have been made in order to reach the design criteria. As the result of this battery packaging design and analysis, the objective to design battery packaging and select the suitable battery packaging, analysis on the faster type design heat transfer from battery packaging to outside of the car can be achieved.

ABSTRAK

Kotak bateri adalah kotak dimana bateri seperti Lead-acid atau Lithium-ion disimpan. Kebiasaannya kotak bateri digunakan untuk kenderaan yang menggunakan tenaga elektrik. Projek ini fokus kepada kereta Proton Iswara dimana kereta ini ingin ditukar daripada menggunakan bahan api petrol kepada elektrik. Elektrik motor telah dipasang dalam kereta proton iswara, oleh itu pemilihan bateri adalah penting supaya jumlah voltan, kuasa dan arus yang sesuai dengan spesifikasi motor tercapai. Sistem penyejukan kotak bateri penting dalam memastikan suhu bateri adalah tidak melebihi suhu operasi bateri. Ini kerana, jika suhu yang berkumpul dalam kotak bateri melebihi suhu operasi bateri, bateri akan rosak dan melibatkan kos yang tiggi untk menyelenggara bateri yang rosak. Projek ini menghasilkan tiga rekaan kotak bateri untuk mencapai rekaan yang sesuai sebagai kotak bateri kenderaan elektrik. Antara kriteria yang perlu ada pada kotak bateri ialah kos yang murah, berat yang sesuai, kekosongan tempat dalam kereta proton iswara dan kos menyelenggara kerosakan bateri dan kotak bateri. Contoh pada sistem penyejukan, kesan pada berat, kos dan penyelenggaraan adalah tinggi. Terdapat dua jenis sistem penyejukan, pertama menggunakan cecair penyejuk dan jenis kedua menggunakan udara sebagai bahan penyejuk. Sistem penyejuk cecair lebih member kesan pada kawalan suhu di dalam kotak bateri, tetapi jenis penyejukan cecair mempunyai banyak kekurangan seperti memerlukan banyak alat untuk siap, kos yang tinggi dalam pemasangan dan juga penyelenggaraan. Sistem ini juga boleh menyebabkan kebocoran pada cecair dan boleh merosakkan kotak bateri jika cecair bertindak balas dengan bahan membuat kotak bateri. Sistem penyejukan yang menggunakan angin kurang keberkesanan berbanding cecair penyejuk, tetapi mempunyai banyak kelebihan seperti kos yang rendah, kurang berat dan juga mudah untuk diselenggara. Oleh itu, projek ini fokus pada sistem penyejukan jenis angin, untuk memilih susunan kipas sedut angin dan kipas bebas angin yang paling memberi kesan pada penurunan dan kawalan suhu di dalam kotak bateri supaya kedua – dua jenis sistem penyejukan memberikan perbezaan yang kecil. Hasil daripada rekaan tiga jenis kotak bateri dan pemilihan kotak bateri yang paling cepat mengeluarkan haba daripada kotak bateri dapat dicapai.

TABLE OF CONTENTS

CHAPTER 3 DESIGN CONSIDERATION OF BATTERY PACKAGING

CHAPTER 4 FINAL DESIGN OF PROTON ISWARA BATTERY PACKAGING

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

P	Power
V	Voltage
I	Current

LIST OF ABBREVIATION

EV	Electric vehicle
FEA	Finite Element Analysis
ZEV	Zero Emission Vehicle

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Today, as human being transportation become an important role for getting a comfortable life. But, human not realize that next 50 years, global population will increase from 6 billion to 10 million and in order aspects, the number of vehicles will increase from 700 million to 2.5 billion [Husain, 1964]. If all these vehicles are propelled or get their sources energy by internal combustion engines (ICEs), then the fuel are out of source. The gloomy answer to these hard questions compel human to strive for sustainable road transportation for 21st century [Husain, 1964].

An electric vehicle (EV) is a vehicle with one or more electric motors for propulsion. This is also referred to as an electric drive vehicle. The motion may be provided either by wheels or propellers driven by rotary motors, or in the case of tracked vehicles, by linear motors. Unlike an internal combustion engine (ICE) that is tuned to specifically operate with a particular fuel such as gasoline or diesel, an electric drive vehicle needs electricity, which comes from sources such as batteries or a generator. This flexibility allows the drive train of the vehicle to remain the same, while the fuel source can be changed [Husain, 1964].

The idea of hybrid vehicles is not a recent development, early 1960s, several companies attempted to develop bipolar lead (acid batteries) for hybrid-electric vehicles [Husain, 1964]. Hybrid vehicles have the potential to increase fuel economy by using a primary engine operating at a constant power to supply average power requirements and a surge power unit for peak power demands and to recover braking energy. But until now, there have no detailed system optimization analysis has been performed for hybrid electric vehicles.

Transportation becomes the major contributor to multiple global environmental problems such as greenhouse effect-gas emissions and urban pollution. The hybrid vehicle typically achieves greater fuel economy and lower emissions than conventional internal combustion engine vehicles (ICEVs), in terms of fewer emissions being generated. These savings are primarily achieved by four elements of a typical hybrid design. First, recapturing energy normally wasted during braking. Second, having significant battery storage capacity to store and reuse recaptured energy. Third, shutting down the gasoline or diesel engine during traffic stops or while coasting or other idle periods and last one is relying on both the gasoline (or diesel engine) and the electric motors for peak power needs resulting in a smaller gasoline or diesel engine sized more for average usage rather than peak power usage.

These features make a hybrid vehicle particularly efficient for city traffic where there are frequent stops, coasting and idling periods. In addition noise emissions are reduced, particularly at idling and low operating speeds, in comparison to conventional gasoline or diesel powered engine vehicles [M.H., Johns, 1996]. For continuous high speed highway use these features are much less useful in reducing emissions. Vehicles which have significant idle periods and only occasional needs of peak power like railroad switching locomotives or repeated lifting and lowering cycles like Rubber Tire Gantry's are also good candidates for hybrid systems resulting in potentially significant fuel and emission savings. The detail of electric vehicle packaging is discussed in the 1.2 Project background.

1.2 PROJECT BACKGROUND

This project is focus on battery packaging for electric vehicle. Some of the battery packaging is referring to the TESLA car and CHEVROLET VOLT that is the electric vehicle that already available in market.

1.3 PROJECT PROBLEM STATEMENT

The performance of the EV depends on the performance of its high-voltage battery pack. Battery temperatures influences are availability of discharge power (for startup and acceleration), energy, and charge acceptance during energy recovery from regenerative braking. These affect vehicle drivability. Temperature also affects the life of the battery and its replacements frequency. Therefore, batteries should operate within temperature range that is optimum for performance and life.

The optimum operating temperature range varies with battery type. The batteries that could be used for EV's are lead acid, nickel metal hybrid (NiMH), and lithium ion (Li-Ion). Today, Li-Ion is the leading choice because the batteries perform well, are safe, and are durable. Usually, the optimum battery temperature range (according to the battery manufacturer) is much narrower than the vehicle manufacturer's specified operating range. For example, the operating temperature for a lead acid battery should be 25°C–45°C, however, the specified vehicle operating range could be -30°C– 60°C. The goal of a thermal management system in an EV is to maintain an acceptable temperature range in a battery packaging with even temperature distribution. However, the pack thermal management system has to meet the vehicle manufacturer's requirement, it must compact, light weight, low cost, easily packaged, and compatible with location.

A thermal management system may use air for heating, cooling, liquid for cooling/heating, insulation, thermal storage such as phase change materials, or a combination of these methods. The material selection are also important in order to make the battery packaging are meet the requirement of the total heat. Therefore, EV must be thermally managed for hot and cold climates and seasons. They must be cooled (by air or liquid) to maintain an acceptable lifespan [Ahmad Pesaran, 2003].

1.4 PROJECT OBJECTIVES

i. To design the battery packaging of Proton Iswara.

1.5 PROJECT SCOPE

i. Measure the available space in Proton Iswara at the University Malaysia Pahang mechanical lab.
ii. Design the battery packaging by using Solid works.
iii. Identify the type of material selection suitable for battery packaging.
iv. Identify the best design of a battery packaging.

1.6 OVERVIEW OF THE THESIS

This thesis is about battery packaging system for electric vehicle. In chapter 1, the project background, problem statement of battery packaging, objectives and project scopes will discuss. In chapter 2, overview of electric vehicle battery packaging are detail in the history of electric vehicle and also the type of the battery that will use in electric vehicle. The battery packagings that already exist in industry are also explained in chapter 2. The design criteria are explain in chapter 3, the available space of Proton Iswara car are, material selection for battery packaging and also cooling system type are discuss in chapter 3. For result and discussions of battery packaging is in chapter 4. This chapter 4 is concluding the type of connection between batteries, comparison of the design and also analysis performance. The last chapter is chapter 5, this chapter is conclusion for overall project and also recommendations for future research.

CHAPTER 2

OVERVIEW OF ELECTRIC VEHICLES BATTERY PACKAGING

2.1 INTRODUCTION

This chapter will explain about the idea of propulsion system in electric vehicles which consists of the history of electric vehicle, type of batteries and the detail of the battery that will use and already use in electric vehicle.

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2.2 HISTORY OF ELECTRIC VEHICLE

In the late 1890s electric vehicles (EVs) outsold gasoline cars. EVs dominated the roads and dealer showrooms. Some automobile companies like Oldsmobile and Studebaker actually started out as successful EV companies, only later transitioning to gasoline-powered vehicles. In fact, the first car dealerships were exclusively for EVs.

Early production of EVs, like all cars, was accomplished by hand assembly. In 1910, volume production of gasoline powered cars was achieved with the motorized assembly line. This breakthrough manufacturing process killed off all but the most well-financed car builders. Independents, unable to buy components in volume died off. The infrastructure for electricity was almost non-existent outside of city boundaries limiting EVs to city-only travel. Another contributing factor to the decline of EVs was the addition of an electric motor (called the starter) to gasoline powered cars – finally removing the need for the difficult and dangerous crank to start the engine. Due to these factors, by the end of World War I, production of electric cars stopped and EVs became niche vehicles – serving as taxis, trucks, delivery vans, and freight handlers.

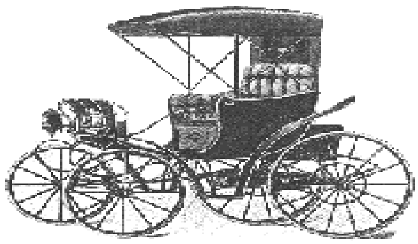

Figure 2.1: Some of the newer EV's that made early 1902 by wood [James Larminie, 2003].

In 1916, a man by the name of Woods invented the first hybrid car, combining an electric motor and an internal combustion engine.

In the late 1960s and early 1970s, there was a rebirth of EVs prompted by concerns about air pollution and the OPEC oil embargo. In the early 1990s, a few major automakers resumed production of EVs – prompted by California's landmark Zero Emission Vehicle (ZEV) Mandate.

Those EVs were produced in very low volumes – essentially hand-built like their early predecessors. However, as the ZEV mandate was weakened over the years, the automakers stopped making EVs – Toyota was the last major auto maker to stop EV production in 2003[James Larminie, 2003].

2.3 ELECTRIC VEHICLE BATTERIES

In the past, most electric vehicle has been powered by lead acid batteries. The main shortcoming attributed to these batteries is low specific energy. The thermal properties of lead acid batteries have been considered to be nearly ideal, because they operate near ambient temperature and in most electric vehicle are required to be neither insulated nor cooled. Batteries that must operate at several hundred degrees Celsius are considered to be at a disadvantage compared to those that operate at ambient temperatures.

Now, however as battery developers seek to produce batteries meet the goals set by U.S Advanced Battery Consortium (USABC, 1991), the thermal requirement of batteries are being more critically considered. The need to provide adequate battery power for acceleration after long idle periods under serve, cold weather conditions may require insulation even for “ambient temperature” batteries such as lead acid batteries.

2.3.1 Lead Acid Battery

Figure 2.2: Example of lead acid battery [Pesaran A, 1998].

The lead-acid (Pb) batteries that have been around for over a century are extremely heavy (low energy density), environmentally unsafe (lead is toxic), and can only handle up to 200 full charge/discharge cycles before their capacity dips below 80% of original [Pesaran A, 1998].